

Robotics Technology

Perception, User Interfaces and Architecture



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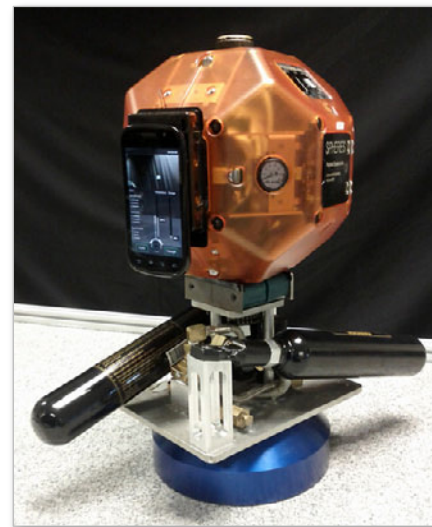
NASA Ames Intelligent Robotics Group

Overview

- 36 researchers (17 Ph.D.'s)
- 25+ student interns yearly
- 80% NASA work
- 20% non-NASA work
- SBIR-STTR (Phase 1, 2, 2E, & 3)

Research themes

- **Automated planetary mapping**
 - Base maps & terrain models
 - Geospatial data systems
- **Exploration user interfaces**
 - Robot & science operations
 - Accessible science data
- **Robots for human explorers**
 - Improve efficiency & productivity
 - Free-flyers, lake lander, & rovers



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IRG Collaborations (2014-2015)

Academic



Commercial



Government



Robotics for Human Exploration

Purpose

- Increase human productivity
- Improve mission planning & execution
- Transfer **some** tasks to robots (tedious, repetitive, long-duration)

Before Crew

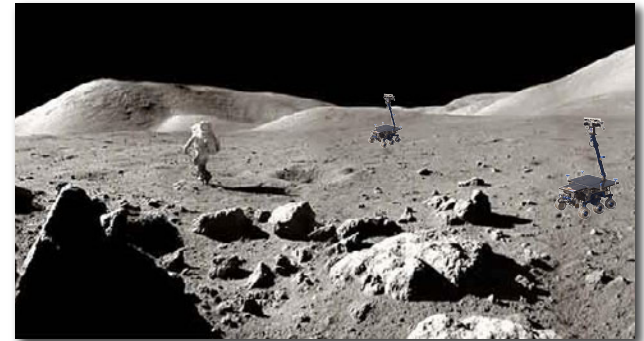
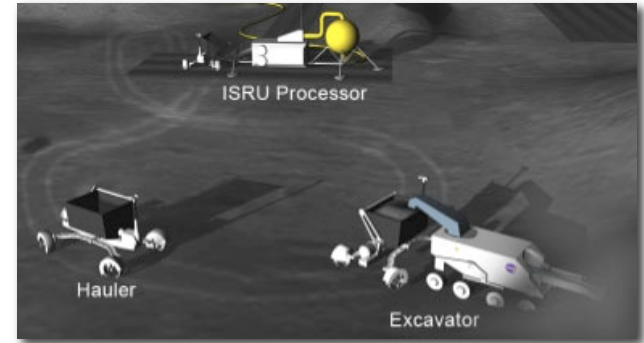
- Recon (scouting) & prospecting
- Site prep, deploy equipment, etc.

Supporting Crew

- Inspection, mobile camera, etc.
- Heavy transport & mobility

After Crew

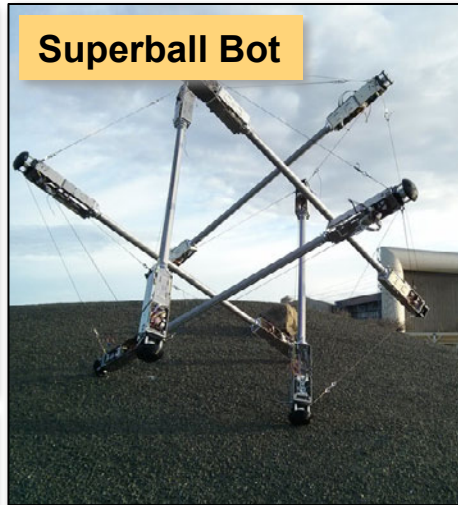
- Follow-up & close-out work
- Site survey, supplementary tasks, etc.



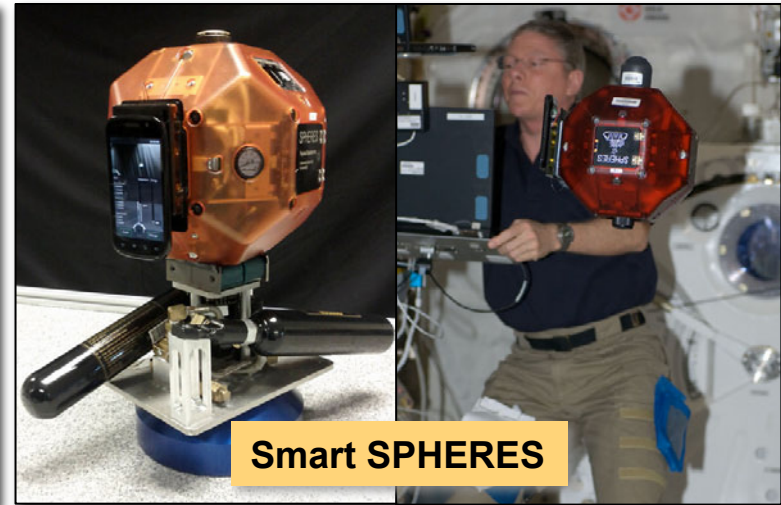
Robots



K10



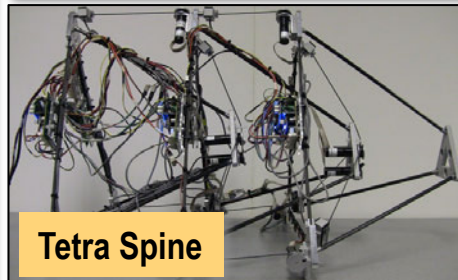
Superball Bot



Smart SPHERES



KREX



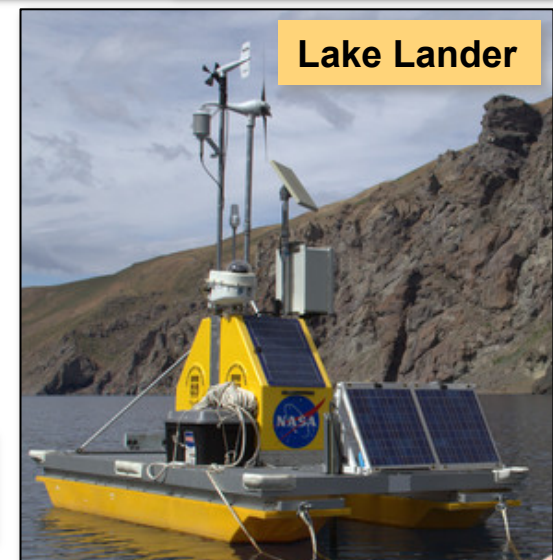
Tetra Spine



K10 mini



**GigaPan
Voyage**



Lake Lander

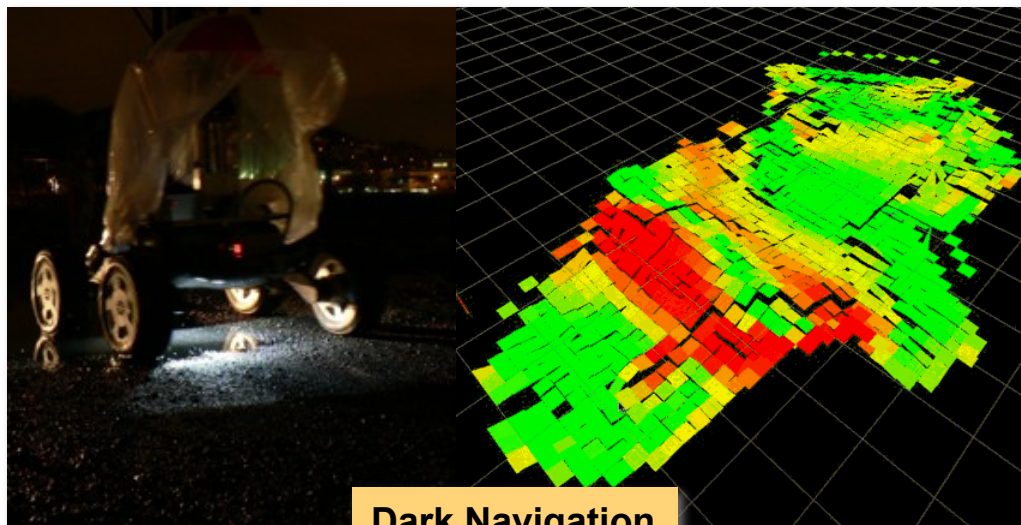
Perception



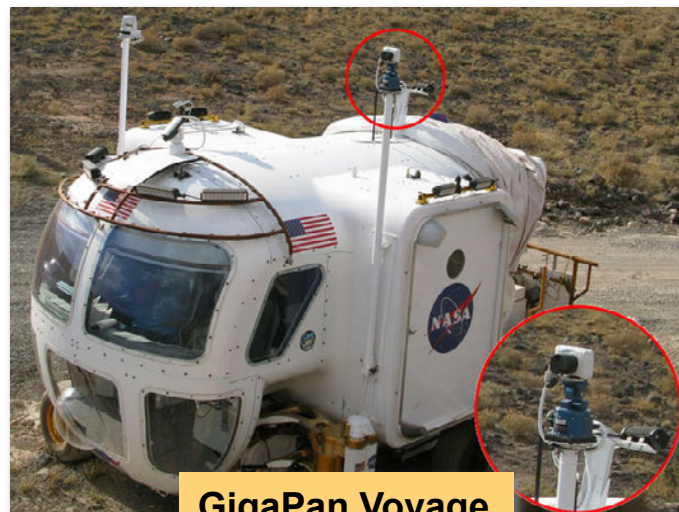
High Dynamic Range Inspection Imaging



DEM Localization

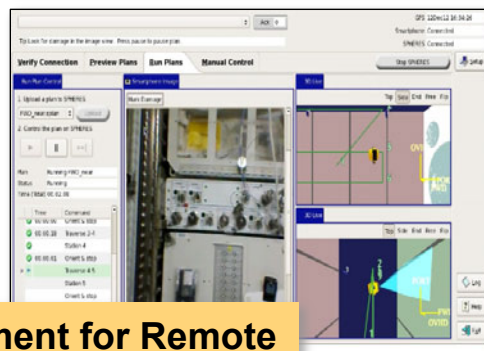
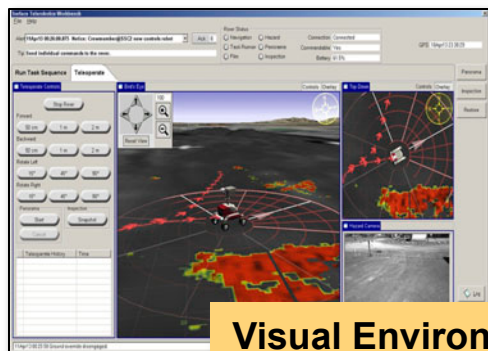
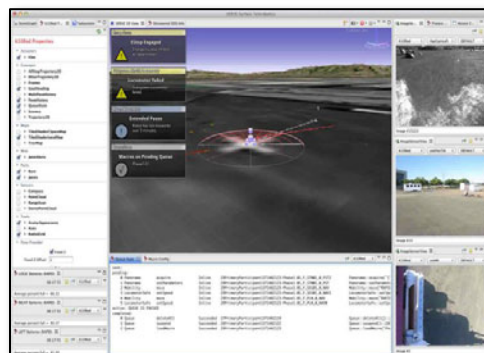
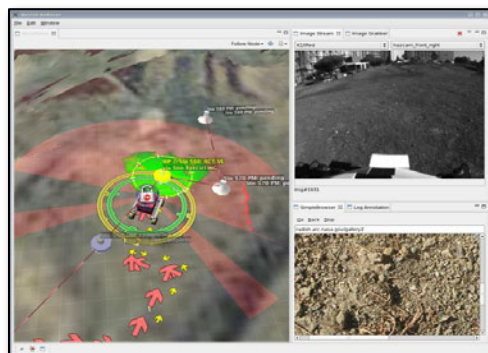
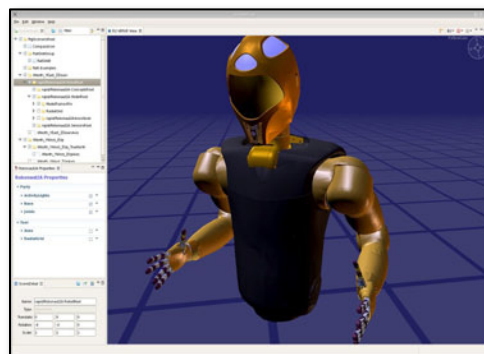
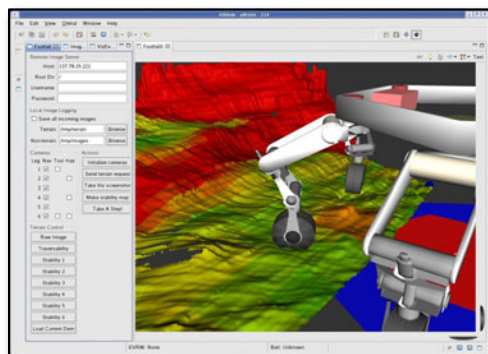


Dark Navigation

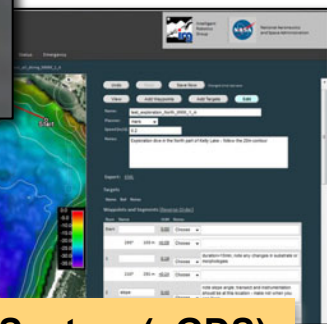
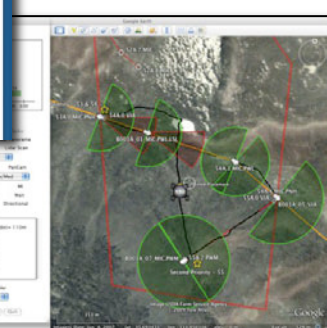
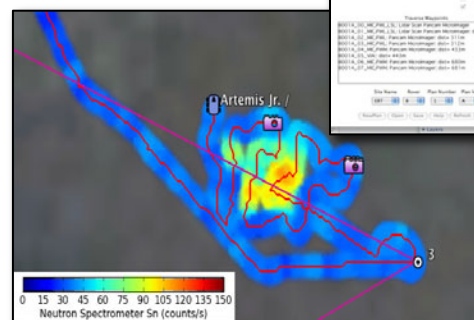
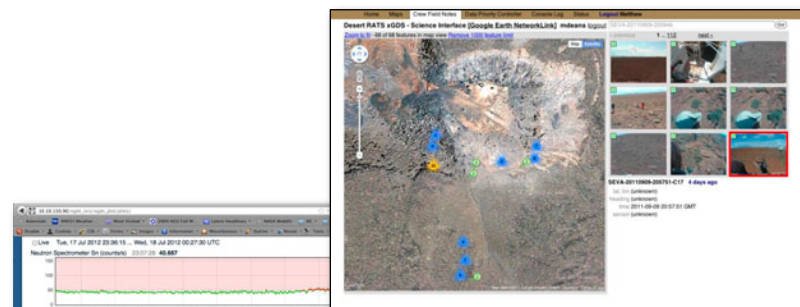


GigaPan Voyage

User Interfaces



Visual Environment for Remote Virtual Exploration (VERVE)

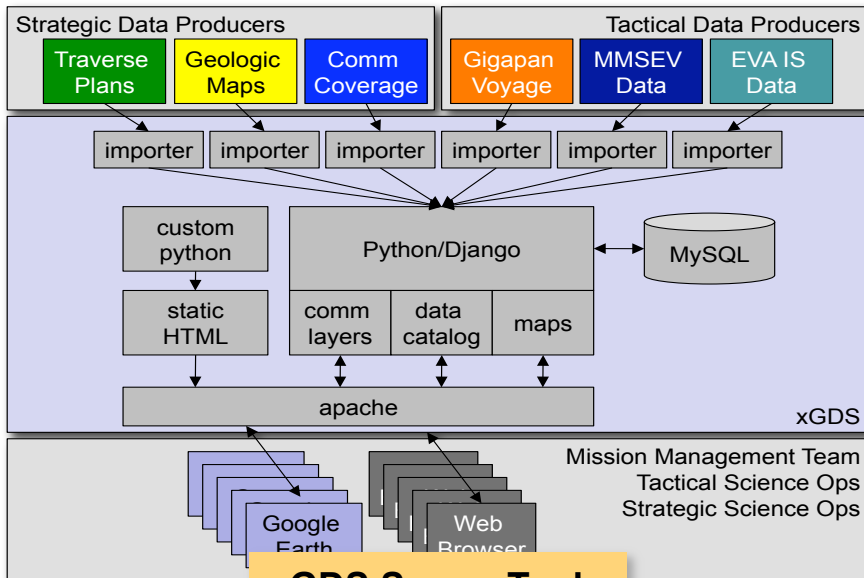
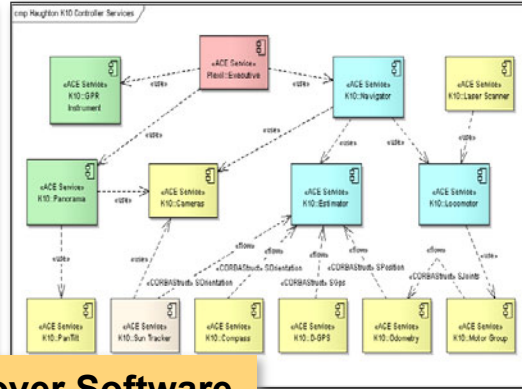


Exploration Ground Data System (xGDS)

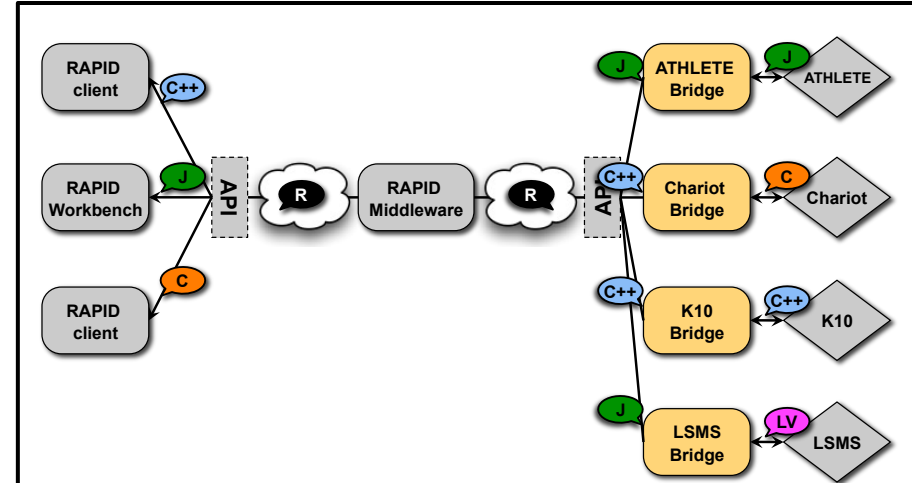
Software Architecture



Rover Software



xGDS Server Tools

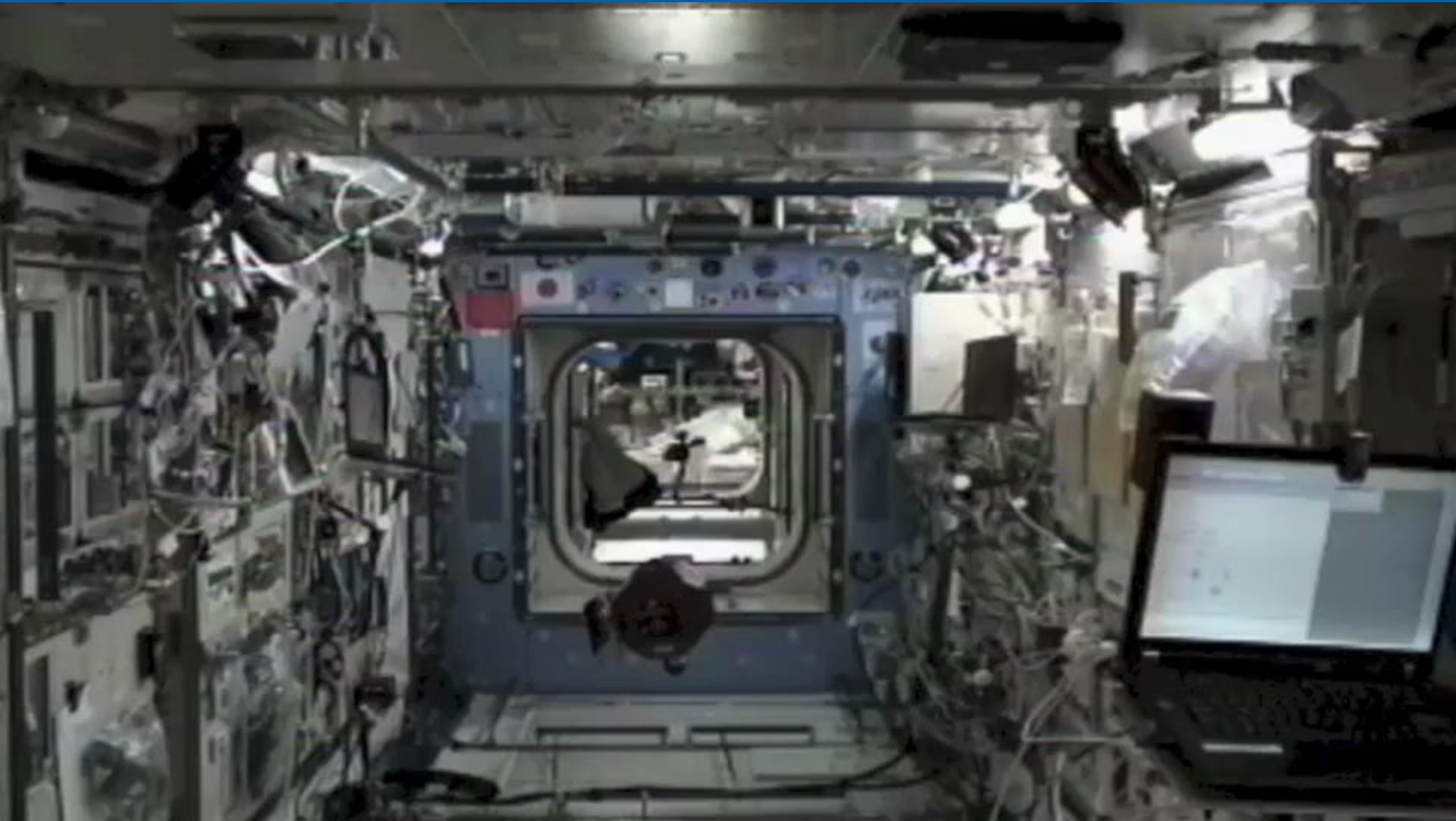


RAPID

K10 Robot at Haughton Crater, Canada



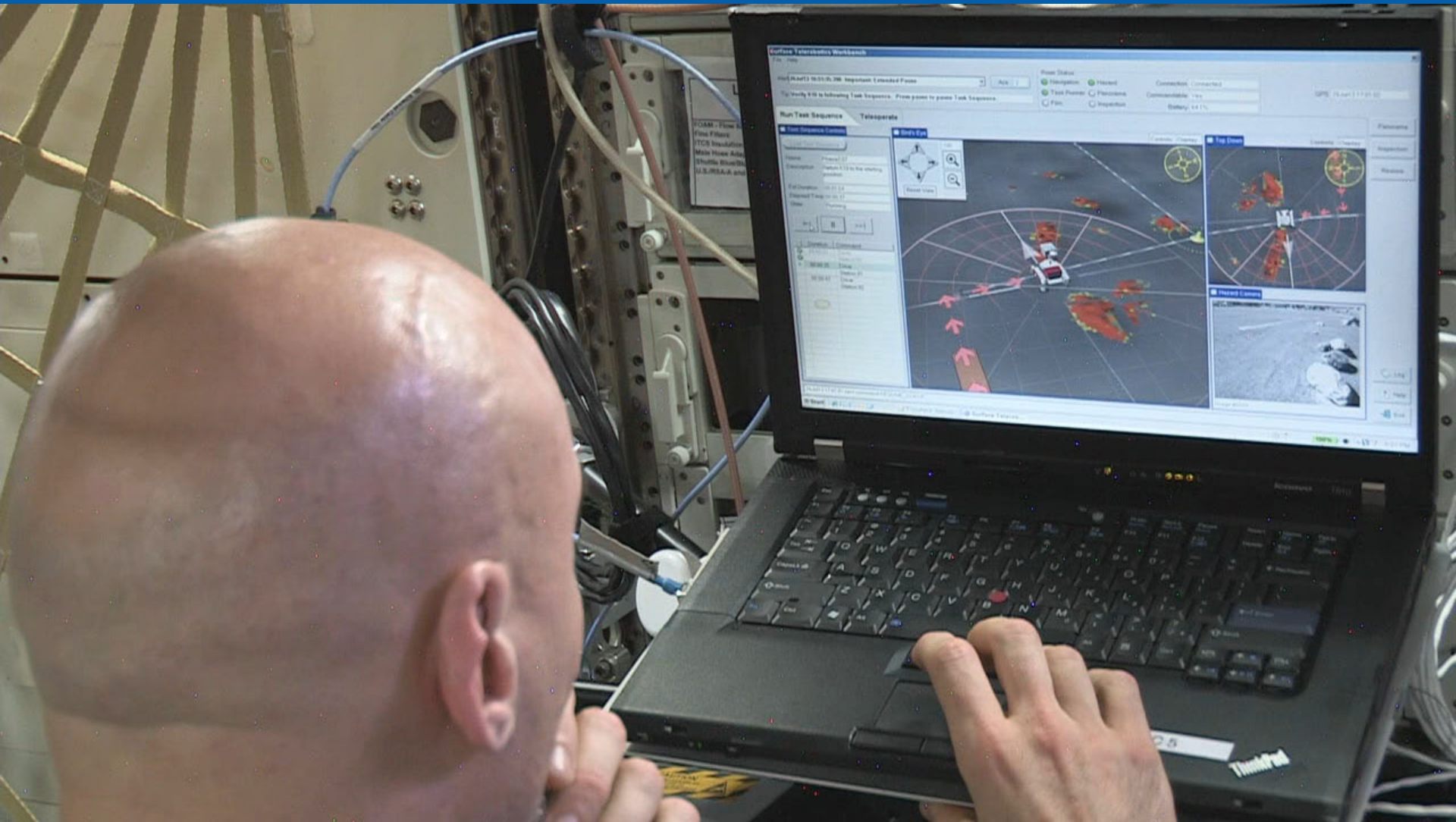
SmartSPHERES on ISS



K10 Remotely Operated from ISS



K10 Remotely Operated from ISS



Mojave Volatiles Prospector



NASA-Nissan Partnership

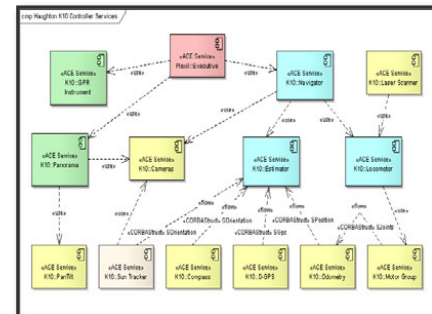
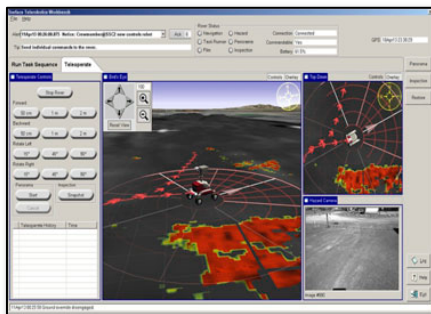
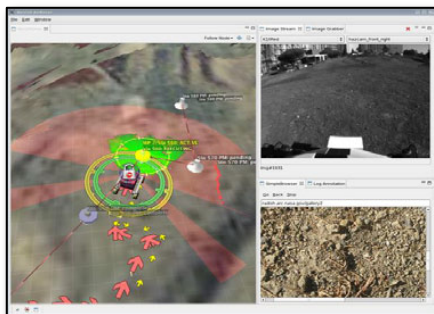
R&D agreement (5 year term)

- Autonomous vehicle systems
- Human-machine interface
- Network-enabled applications
- Software analysis and verification
- Vehicle testing at NASA Ames



Robotics technologies

- Application of NASA algorithms and concepts
- Joint development, testing, and assessment
- Demonstration: fleet management of multiple autonomous vehicles



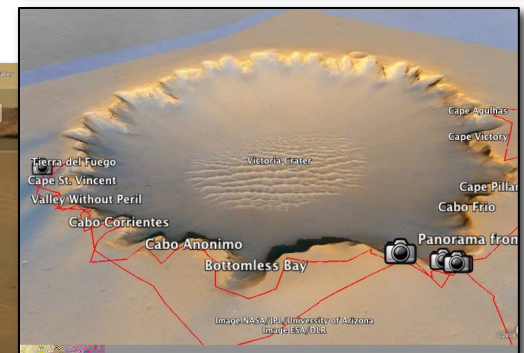
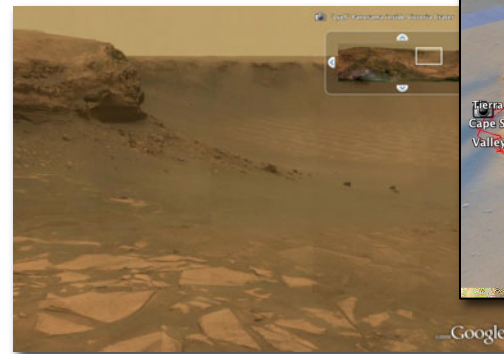
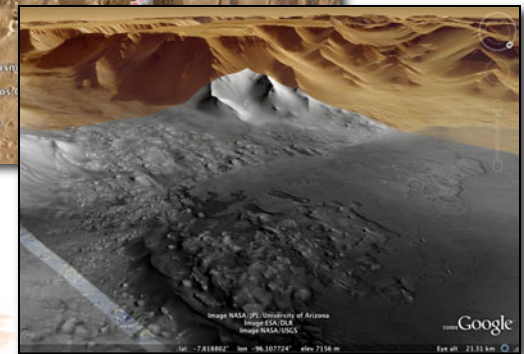
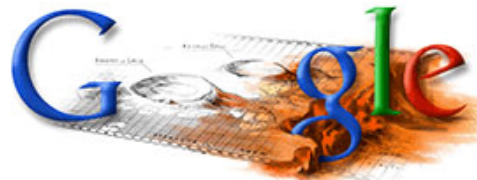
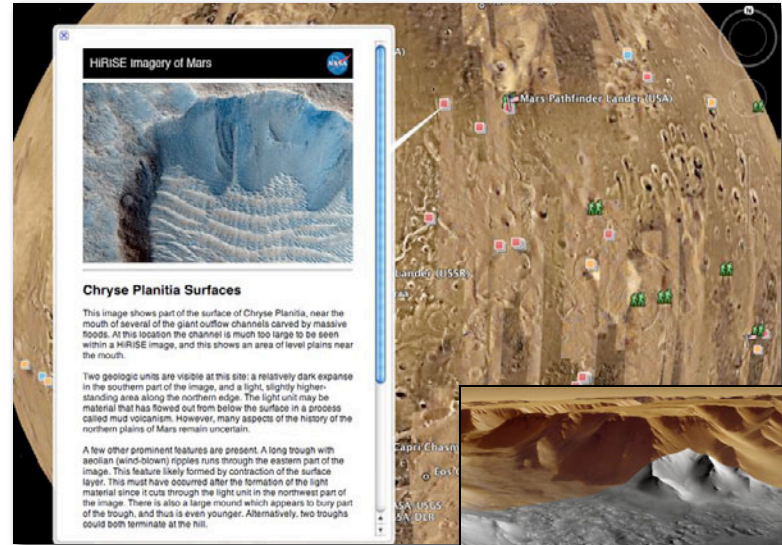
Mars in Google Earth

Explore Mars in 3D

- Released Feb. 2, 2009
- Co-developed with Google
- NASA Ames created content & processing scripts

Content

- Global maps: topography, infrared, historical, etc.
- Imager footprints & overlays (HiRISE, CTX, MOC, ...)
- Mars rover tracks & color panoramas
- Tours (Bill Nye & Ira Flatow)
- Live from Mars: THEMIS
- And much more ...



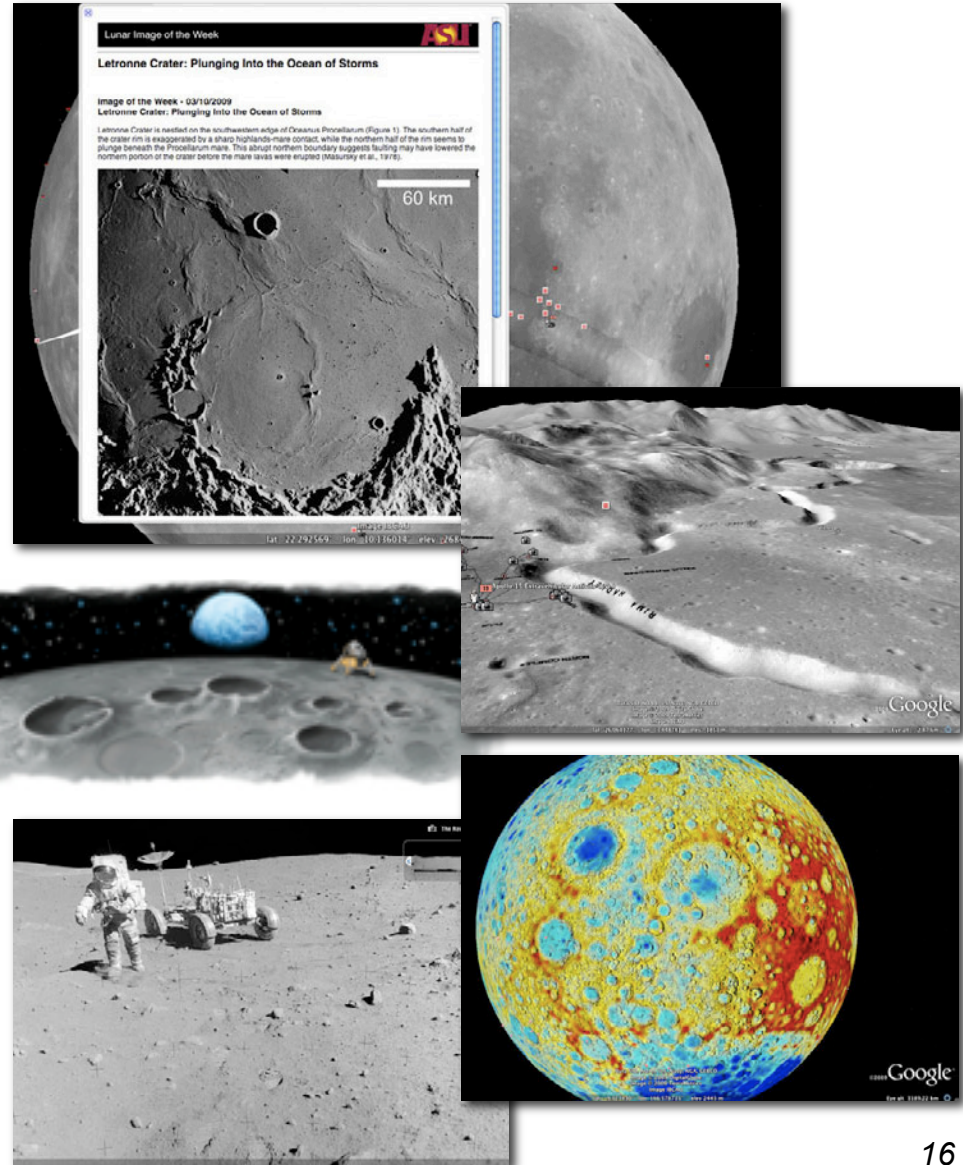
Moon in Google Earth

Explore the Moon in 3D

- Released July 20, 2009
- Co-developed with Google
- NASA Ames created content & processing scripts

Content

- Global maps: topography, geologic, historical, etc.
- Spacecraft imagery: Apollo, Lunar Orbiter, etc.
- 3D models of spacecraft, landers, and crew rovers.
- Tours (Andy Chaikin, Buzz Aldrin & Jack Schmidt)
- And much more ...



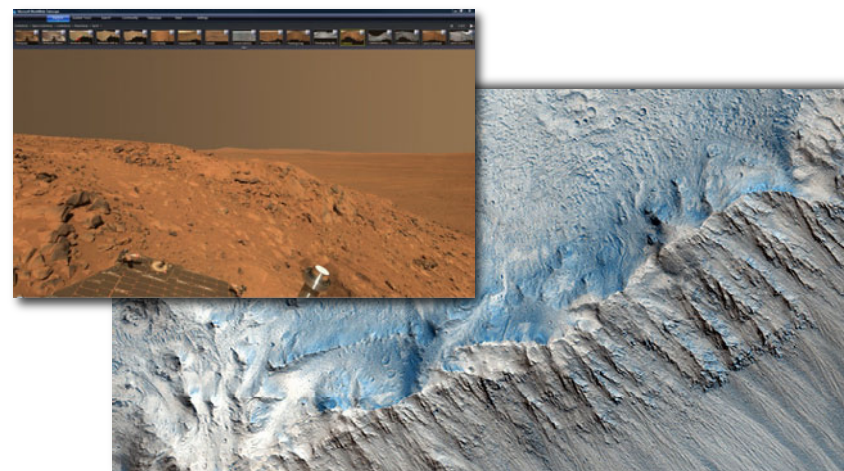
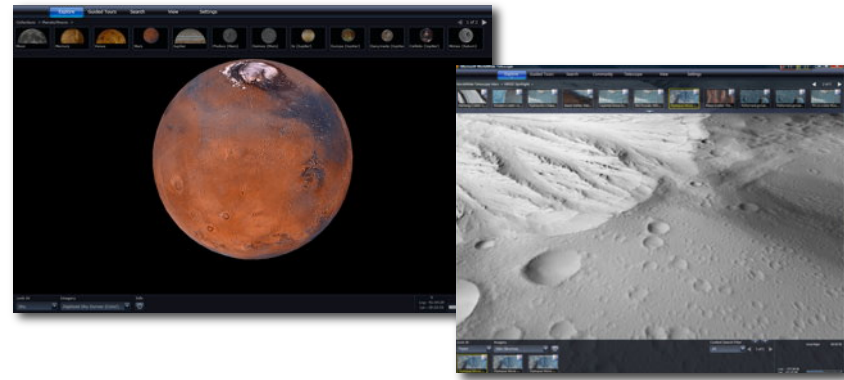
WorldWideTelescope | Mars

Complete HiRISE Mosaic

- Mars Reconnaissance Orbiter HiRISE imager
- 74,000 images
- Each image: 20K x 50K pixels (> 1 GB / image)

Mosaic stats

Tile Dimensions	256 x 256 pixels
Root Tiles / Image	15,000
Tile Space	25 KB
Tiles Total	229 million
Total Mosaic Size	5.7 TB



Ames Stereo Pipeline ... for Earth

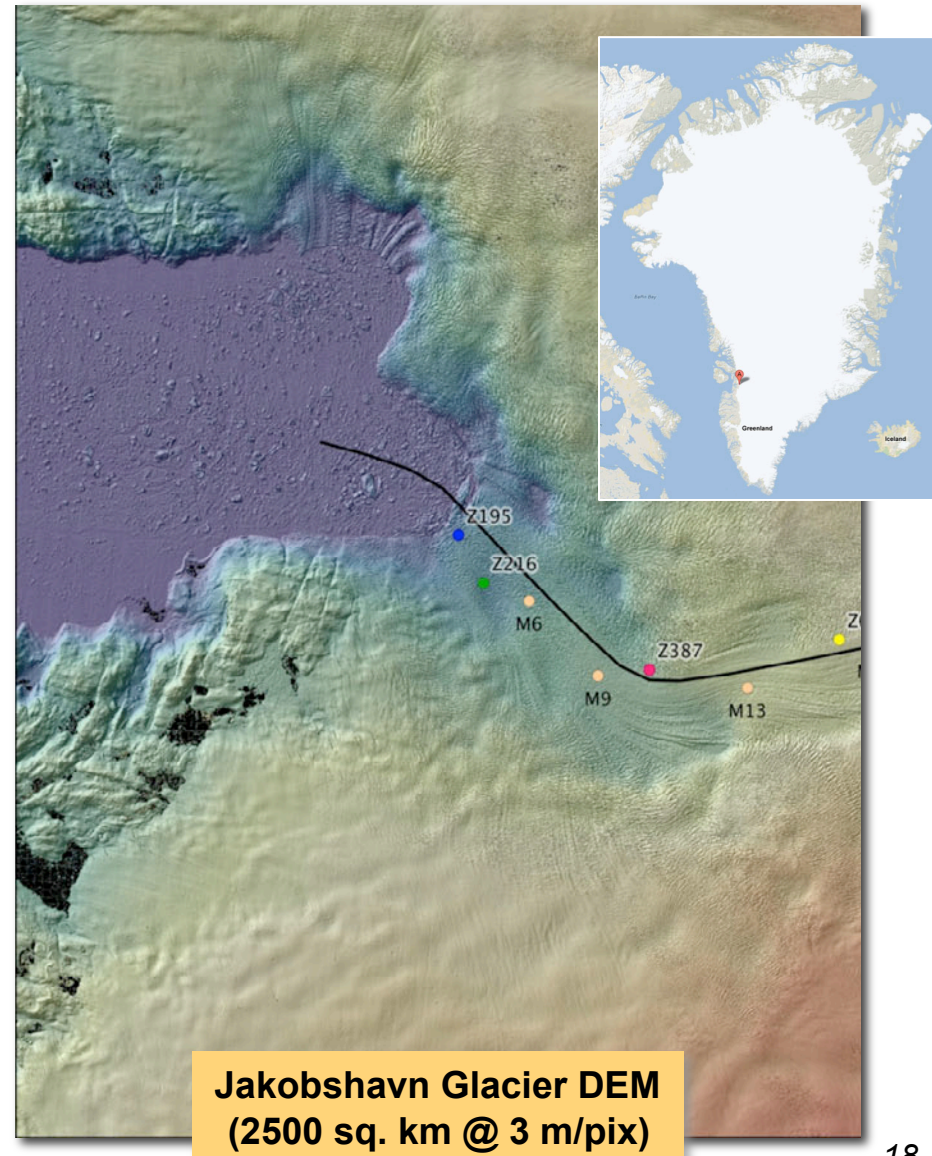
3D terrain modeling

- Digital Elevation Models (DEM) produced from satellite images
- 60% success rate processing Digital Globe stereo pairs without human input
- Available as open-source (Apache 2 license)
- Binaries for Linux & OS-X

Earth science studies

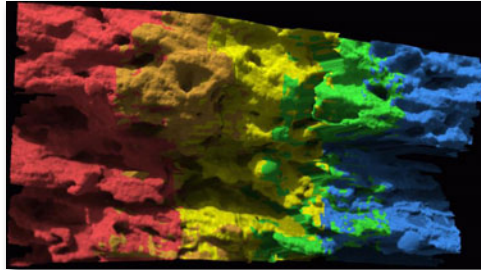
- Glacier volume changes and movement
- Evolution of subglacial lakes
- Sea ice movements
- Climate change measurements

irg.arc.nasa.gov/ngt/stereo



Open Source Software

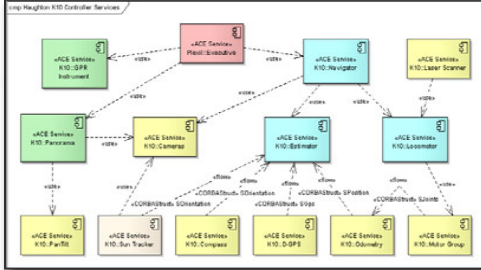
Vision Workbench



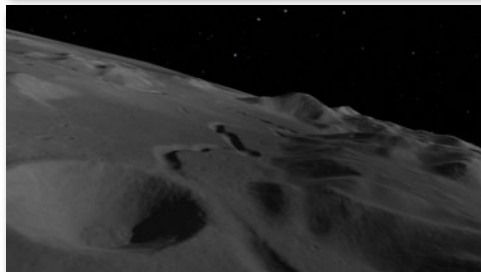
RoverSW



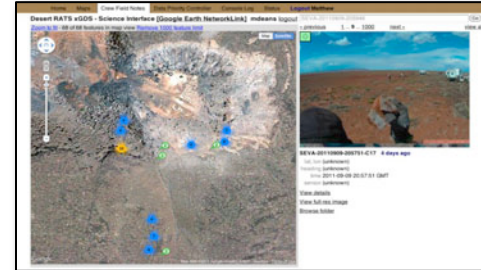
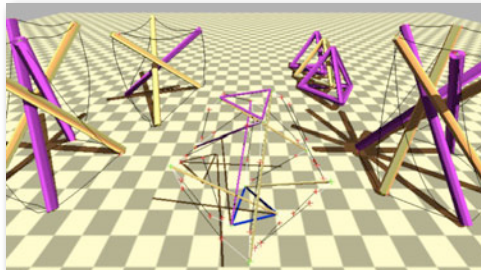
NOSA 1.3



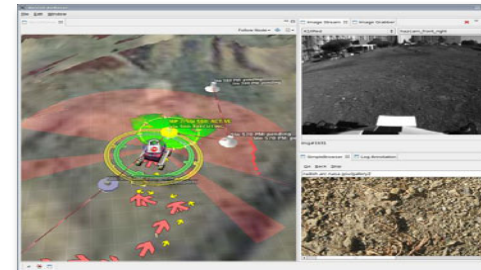
Neo Geography Toolkit (Ames Stereo Pipeline)



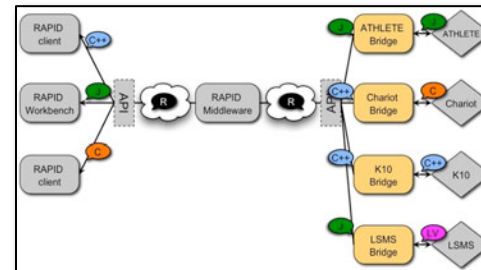
NASA Tensegrity Robotics Toolkit



Exploration Ground Data Systems (xGDS)



Visual Environment for Remote Virtual Exploration (VERVE)



RAPID (NASA robot middleware)



Questions?



Intelligent Robotics Group

Intelligent Systems Division
NASA Ames Research Center

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